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# OPERATING AND SERVICE MANUAL

## MODEL 111

## VOLTAGE DIVIDER

SECOND EDITION (6/25/69)

WESTON-LEXINGTON
Weston Instruments Division
17 Hartwell Avenue
Lexington, Massachusetts 02173

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# W A R R A N T Y

Weston-Lexington warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this Warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose, and to replace any defective parts thereof. This Warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed to the customer. In this case, an estimate will be submitted before the work is started.

IN ANY FAULT DEVELOPS, THE FOLLOWING STEPS SHOULD BE TAKEN:

1. Notify us giving full details of the difficulty; include the Model number and serial number. On receipt of this information, we will give you service data or shipping instructions.
2. On receipt of shipping instructions, forward the instrument prepaid to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

# SECTION 1

# DESCRIPTION AND SPECIFICATIONS

## 1.1. GENERAL DESCRIPTION

The Model 111 plug-in is a high-resolution voltage divider providing good accuracy and exceptional frequency response when used with the Weston 100 series Precision Oscillators at a constant 200Ω output impedance over the frequency range from 10Hz to 100kHz. The plug-in consists of a three-decade plus vernier wide-band voltage divider which divides the output of the oscillator from 0 to 12 volts over four multiplier ranges. Complete specifications are given in Section 1.3. The decade divider has settings from 0.00 to 12.10 (11.XX) with a continuously variable vernier covering 0.000 to 0.00X. The four multiplier ranges are X1, X0.1, X0.01 and X0.001. Resolution of better than one microvolt is available on the X0.001 multiplier range with the vernier covering the range from 0 to 10 microvolts. A floating output connector is included which isolates the divider circuit ground from the chassis ground and allows for floating operation when the oscillator switch is in the floating position. (See 100 series oscillator manual for floating operation.)

## 1.2. USES

Flat frequency-response, constant output-impedance, high resolution, and accuracy make the combination of the Model 111 plug-in and Weston Precision Oscillator useful in such applications as frequency-response testing from 1mV to 12 volts, distortion analysis, and measuring the gain of an amplifier or system. With the fixed high-level reference output available from the basic oscillator and Model 111 plug-in providing low-level

signals, suppressed-carrier systems which utilize phase-sensitive demodulators can be easily evaluated. With a quadrature reference also available from the oscillator, quadrature rejection of phase-sensitive systems can also be analyzed.

## 1.3. SPECIFICATIONS

| | |
|---|---|
| Number of Phases: | 1 (ØA) |
| Controls: | 4 decade divider with a X1, X0.1, X0.01 and X0.001 range multiplier which provides 1 microvolt per division in the X0.001 multiplier position. 4th decade is a potentiometer. |
| Output Voltage Settings: | 0 to 12.11 volts (X1 range)<br>0 to 1.211 volts (X0.1 range)<br>0 to 0.1211 volts (X0.01 range)<br>0 to 0.01211 volts (X0.001 range) |

| Total Frequency Response Including Oscillator | | | | |
|---|---|---|---|---|
| Range Position | 10Hz-20Hz | 20Hz-20kHz | 20kHz-50kHz | 50kHz-100kHz |
| X1‡ | 0.02% ±0.1mV | 0.01% ±0.15mV | 0.02% ±0.2mV | 0.05% ±0.3mV |
| X0.1‡ | 0.02% ±20μV | 0.01% ±20μV | 0.05% ±30μV | 0.07% ±50μV |
| X0.01‡ | 0.02% ±2μV | 0.02% ±2μV | 0.07% ±10μV | 0.1% ±20μV |
| X0.001 | 0.02% ±1μV | 0.05% ±1μV | 0.1% ±3μV | 0.15% ±5μV |

| | |
|---|---|
| Accuracy at 1kHz‡ | ±0.25% X1 range<br>±0.35% X0.1 range<br>±0.45% X0.01 range<br>±0.55% X0.001 range |

‡With first digit not set to zero

| | |
|---|---|
| Amplitude Stability Vs. Temperature‡ (total including oscillator): | ±0.03%/°C |
| Output Impedance: | 200Ω ±0.2% |
| Available Output Current: | Matched 200Ω load; 30mA max.<br>*Short circuit load; 60mA max. |
| Maximum Input Current to Plug-in:* | No load on plug-in; 23mA in X1, 27mA in X0.1, X0.01 and X0.001.<br>Matched 200Ω load; 47mA.<br>Plug-in "short circuit" load, 9V setting and below; 55mA.<br>*Plug-in "short circuit" load; above 9V setting; 78mA. |
| Output: | Front panel BNC connector. |
| Temperature Range for Specified Performance: | 15° - 40°C |
| Operating Temperature Range: | 0° - 52°C |
| Shock and Vibration: | Designed to meet all performance specifications after being subjected to the applicable shock and vibration requirements of MIL-T-945. |
| Dimensions and Weight: | 4-1/8" h x 5-3/16" w x 5-9/16" d behind front panel (excluding connector); 2-1/2 lbs. |

*Current available from oscillator front panel fixed output in mA equals 60 less plug-in input current. If the input current to the plug-in exceeds 60mA, distortion and frequency response will be slightly degraded due to overloading the oscillator.

## SECTION 2

## INSTALLATION AND OPERATION

### 2.1. INSTALLATION

The plug-in module has been designed to fit into the front panel receptacle on the Precision Oscillator (see Precision Oscillator manual). Before inserting plug-in into the receptacle, place plug-in locking latch (see Figure 2-1) in a position such that the plug-in will slide completely into the receptacle. When fully inserted, the front panel of the plug-in should be flush with the oscillator front panel. Turn locking latch in the clockwise direction to lock the plug-in firmly in place.

### 2.2. OPERATING CONSIDERATIONS

#### 2.2.1. OUTPUT IMPEDANCE

For full accuracy and ease of application, the load impedance should be as high as possible (greater than 400KΩ). The divider itself is calibrated for no load, with a matched 200Ω load, the output voltage will be half the indicated value. For any load ($R_L$), the output voltage equals:

$$\text{Divider output} = \frac{R_L}{R_L + 200} \times \text{dial setting}$$

where $R_L$ is in ohms.

#### 2.2.2. PLUG-IN CURRENT DRAIN WITH LOAD

The output amplifiers in the oscillator are rated at 60mA maximum for full specification. Because their outputs are brought directly to the front panel of the oscillator at a low impedance level, it is possible to draw more than 60mA. Although

this does not harm the amplifiers in any way, the oscillator specifications are no longer maintained. When a divider plug-in is being driven by the amplifiers, the total current available at the low impedance front-panel outputs is reduced by the amount used by the plug-in. The currents for different loads on the divider must be subtracted from the specified 60mA level to determine how much current is still available from the zero impedance output. For the Model 111PM plug-in, only phase A is used, allowing phase B low-impedance oscillator front-panel output to supply 60mA regardless of the load on the divider output. (See specifications, Section 1.3., for input current for different loads).

2.2.3. CAPACITIVE LOADING

A capacitive load on the divider will affect the frequency response of the output voltage from the divider. With capacitive loading, the following formula should be used to calculate additional frequency-response error:

$$\text{Additional \% error} \approx 0.78 f^2 \times 10^{-10} \left[ (C_{ext} + 50)^2 - (50)^2 \right]$$

where: $C_{ext}$ is in pf

f is in kHz

2.3. OPERATING PROCEDURE

a. Insert plug-in into oscillator receptacle on front panel (see Section 2.1.).

NOTE: The oscillator need not be turned off when plug-ins are inserted or removed.

b. Set dials and multiplier switch to the desired voltage (see Section 2.2.1. for heavy loads).

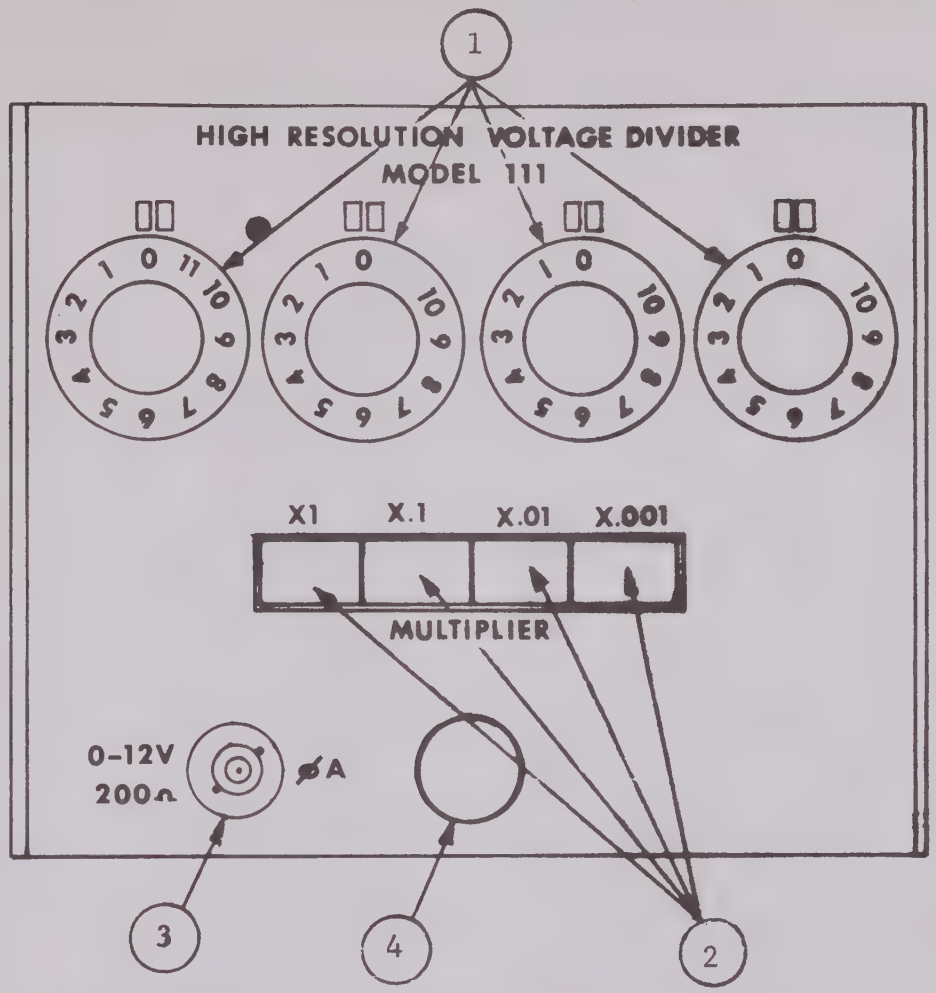
c. Attach load to the output connector on the front of the plug-in.

## 2.4. IMPEDANCE ADAPTORS

Some loads are affected by an impedance mismatch, or frequency response may be degraded due to large capacitive loads. For such cases, impedance adaptors may be necessary. The following is a list of adaptors and their part numbers which are available as accessories:

200Ω to 600Ω adaptor - Weston Part No. 02-117-308

200Ω to 50Ω X10 attenuator - Weston Part No. 02-117-207




1. DIVIDER SWITCHES AND VERNIER (SW10, 11, 12 and R134) divides Precision Oscillator phase A output from 12.10 volt to 1μV when used in conjunction with the multiplier ranges.

2. MULTIPLIER RANGES (SW13, 14, 15 and 16) provide multiplication of divider switches by X1, X0.1, X0.01 and X0.001.

3. OUTPUT (J111) attenuated phase A output of Precision Oscillator.

4. PLUG-IN LOCKING LATCH, turn fully counter-clockwise to insert or remove plug-in, fully clockwise to lock plug-in into oscillator.

Figure 2-1. Front Panel Controls and Connectors

## SECTION 3

## THEORY OF OPERATION

The Model 111 plug-in is shown in simplified form in Figure 3-1, below.

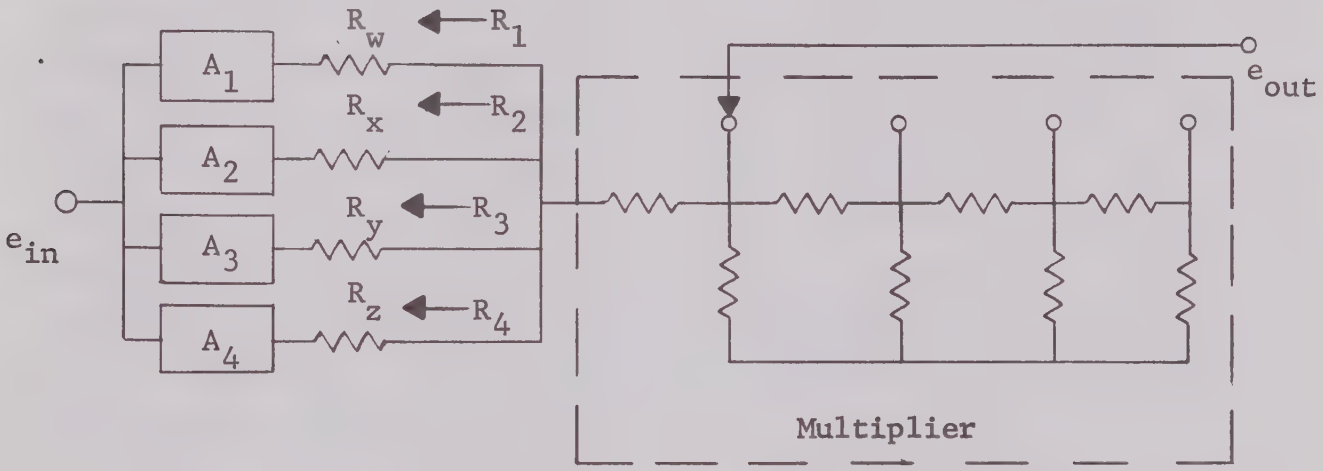



Figure 3-1
Simplified Schematic

Most precision dividers (Kelvin-Varley, etc.) yield fine ratio accuracies, but output impedance varies with setting. This change in loading is not desirable as it seriously affects voltage accuracy under load.

In Figure 3-1, $A_1$ represents a switched potentiometer. Different resistors are selected for each switch position such that $R_1$ is held constant with switch setting (see Schematic 04-117-511-1). $A_2$ and $A_3$ are similar to $A_1$ except that $R_x$ and $R_y$ must also act as weighting resistors such that the full-scale effect of $A_2$ is 1/12 $A_1$ and the full-scale effect of $A_3$ is 1/10 $A_2$. $A_4$ is a true potentiometer whose weighting resistor $R_z$ is large

enough to make $R_4$ essentially constant with potentiometer setting. With this weighting resistor, the full-scale effect of $A_4$ is 1/1200 of $A_1$.

The total effect of $A_1$, $A_2$, $A_3$ and $A_4$ plus their associated resistors is a linear continuously-adjustable divider with constant (±0.25%) output impedance. The multiplier is a simple ladder attenuator with a high degree of shielding between input and output to maintain the frequency response of the divider to low voltage setting. There is, however, still some feedthrough capacitance from input to output at low divider settings and at high frequencies which has been drastically reduced by additional compensation circuitry. Figure 3-2 shows in block diagram form the technique used to reduce this effect. In Figure 3-2, an equal but opposite amount of the signal current is generated by a source which is exactly 180° out of phase with the divider input source. The net result is a drastic reduction in the error caused by the feedthrough capacitance.

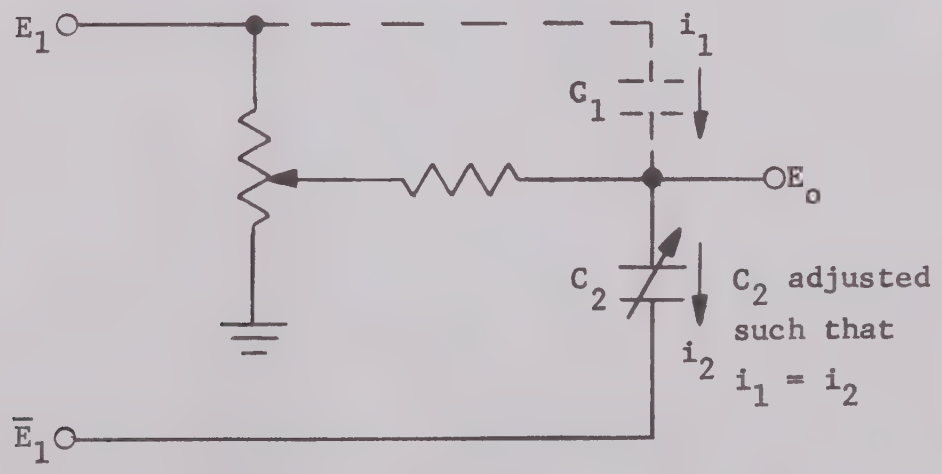



Figure 3-2

Feedthrough Compensation

# SECTION 4

# CALIBRATION

## 4.1. DC PERFORMANCE TEST AND CALIBRATION

The dc performance test setup is illustrated in Figure 4-1. A DC power supply (EDC Model VS-111, or equivalent) and a digital voltmeter (Weston Model 1423, or equivalent) are required for this test. The purpose of this test is to check, and if necessary, calibrate the divider. To perform the test, proceed as follows:

a. Make test setup illustrated in Figure 4-1.
b. Set decade dials and vernier to read 1.000.
c. Set multiplier switch to X1.
d. Apply 12.11 volts to plug-in as shown in Figure 4-1.
e. The output of the divider is now read on the digital voltmeter and should be 1V ±2.5mV. If the output is not within this limit, adjust R13 until the output is within specifications.
f. Set dials to read 2.000.
g. Keep multiplier at X1 position.
h. Read output on digital voltmeter. Output should be 2V ±5mV. Adjust R11 until output is within specifications.
i. Because of interaction between trims, repeat steps b. through h. until all requirements are satisfied.
j. Set dials to read 10.00 and multiplier to X0.1.
k. Read output on digital voltmeter. Output should be 1V ±3.5mV. Adjust R87 until output is within specifications.

l. With dials set to 10.00, set multiplier to X0.01.

m. Read output on digital voltmeter. Output should be 0.1V ±450μV. Adjust R92 until output is within specifications.

n. With dials set to 10.00, set multiplier to X0.001.

o. Read output on digital voltmeter. Output should be 0.01V ±55μV. Adjust R97 until output is within specifications.

p. With multiplier switch set to X1, switch first decade through each position and observe output on digital voltmeter. The output should be within ±0.25% of dial indication.

q. A check on every decade is not necessary. A quick check can be made with the dials set to 1.111 and 1.555 volts and the multiplier switch set to X1. The output should be within ±0.25% of dial reading.

## 4.2. AC PERFORMANCE AND CALIBRATION PROCEDURE

The ac performance and calibration test consists of two parts: a) feedthrough reduction trim, and b) frequency response. Part a should be performed before part b, as feedthrough will affect the divider frequency response.

### 4.2.1. FEEDTHROUGH REDUCTION TRIM

a. Insert plug-in oscillator as outlined in Section 2.1.

b. Remove oscillator top cover (see oscillator manual for instructions).

c. Turn oscillator on and set frequency to 100kHz.

d. Set plug-in dials and vernier to zero and multiplier switch to X1.

e. Measure output on VTVM (H-P Model 400D, or equivalent).

f. If output is greater than 300μV, adjust capacitor C2 in plug-in until output is less than 300μV.

## 4.2.2. FREQUENCY RESPONSE TESTING

The frequency response of the divider is controlled by two factors: 1. The geometry of the divider, and 2. The capacitance and/or inductance in the resistors. Very complicated techniques have been developed to measure divider frequency response at low level settings which would be very difficult to perform in most calibration laboratories. For this reason a two-poing frequency-response test at high level outputs will generally be sufficient to guarantee that geometry and resistors have not changed. Figure 4-2 shows a typical test setup. To perform the test, proceed as follows:

a. Insert plug-in into oscillator.

b. Turn oscillator on and set to 400Hz; set plug-in dials to read 6.000 and multiplier to X1.

c. Connect 5 volt high-frequency thermal converter (HFTC Engelhard Industries Part No. 34970-10C, or equivalent) to the divider output.

NOTE: Because we are only interested in frequency response, the decrease in output voltage due to loading by the converter is inconsequential.

d. Using the HFTC as a transfer device, measure the plug-in output.

e. Set the oscillator frequency to 100kHz and repeat step d. This reading should not exceed ±0.05% of the reading of step d.

f. Set plug-in dials to read 1.000 and multiplier to X1.

g. Using a 1 volt HFTC, repeat steps c., d., and e. The difference between the 400Hz reading and 100kHz reading should not exceed ±0.08%.

h. Step g. may be repeated on the X0.1 multiplier position by setting the divider dials to read 10.000 and the multiplier to X0.1. The 1 volt HFTC would still be used for this test. The difference between the 400Hz, and 100kHz reading should not exceed ±0.075%.

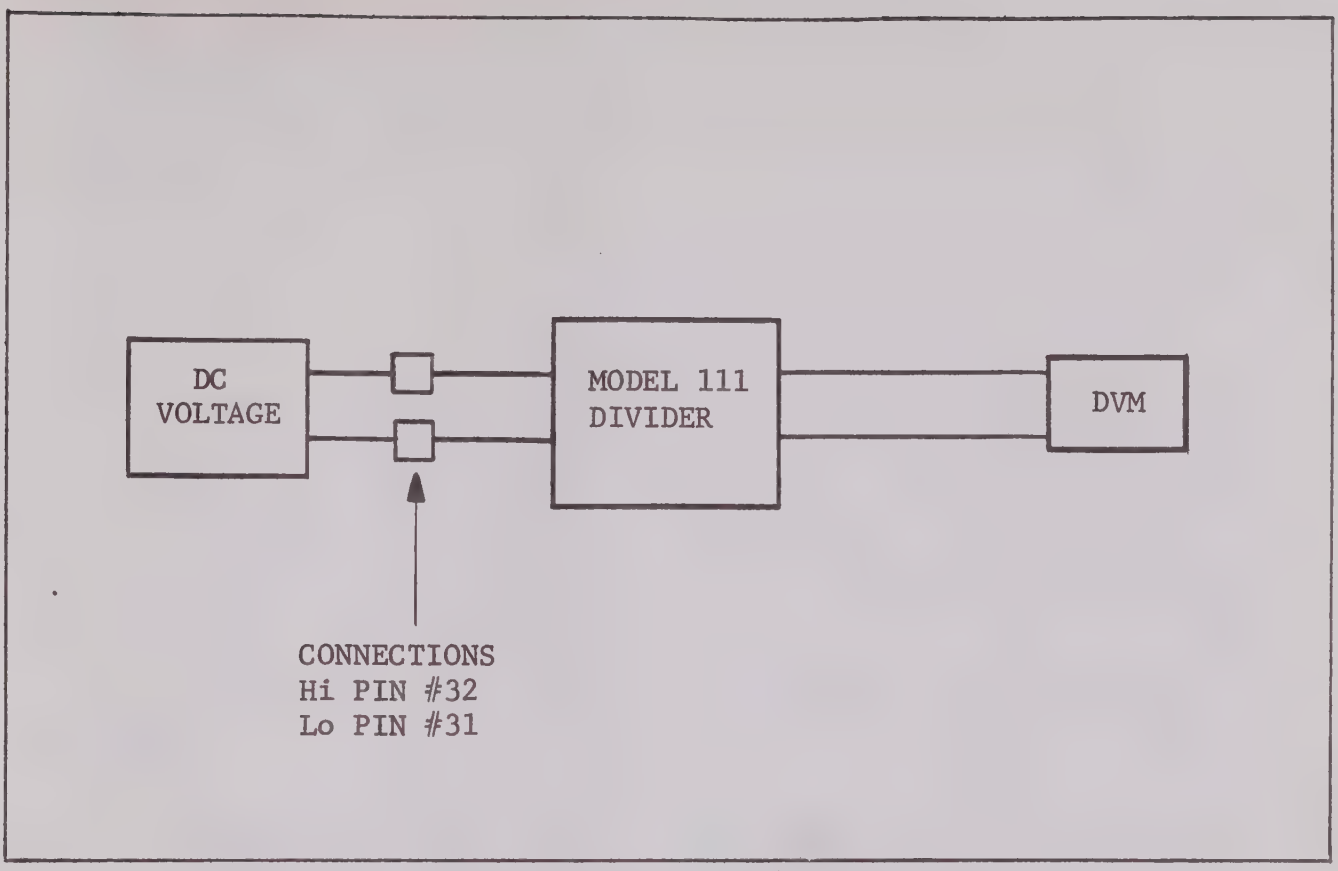



Figure 4-1. DC Performance Calibration Setup

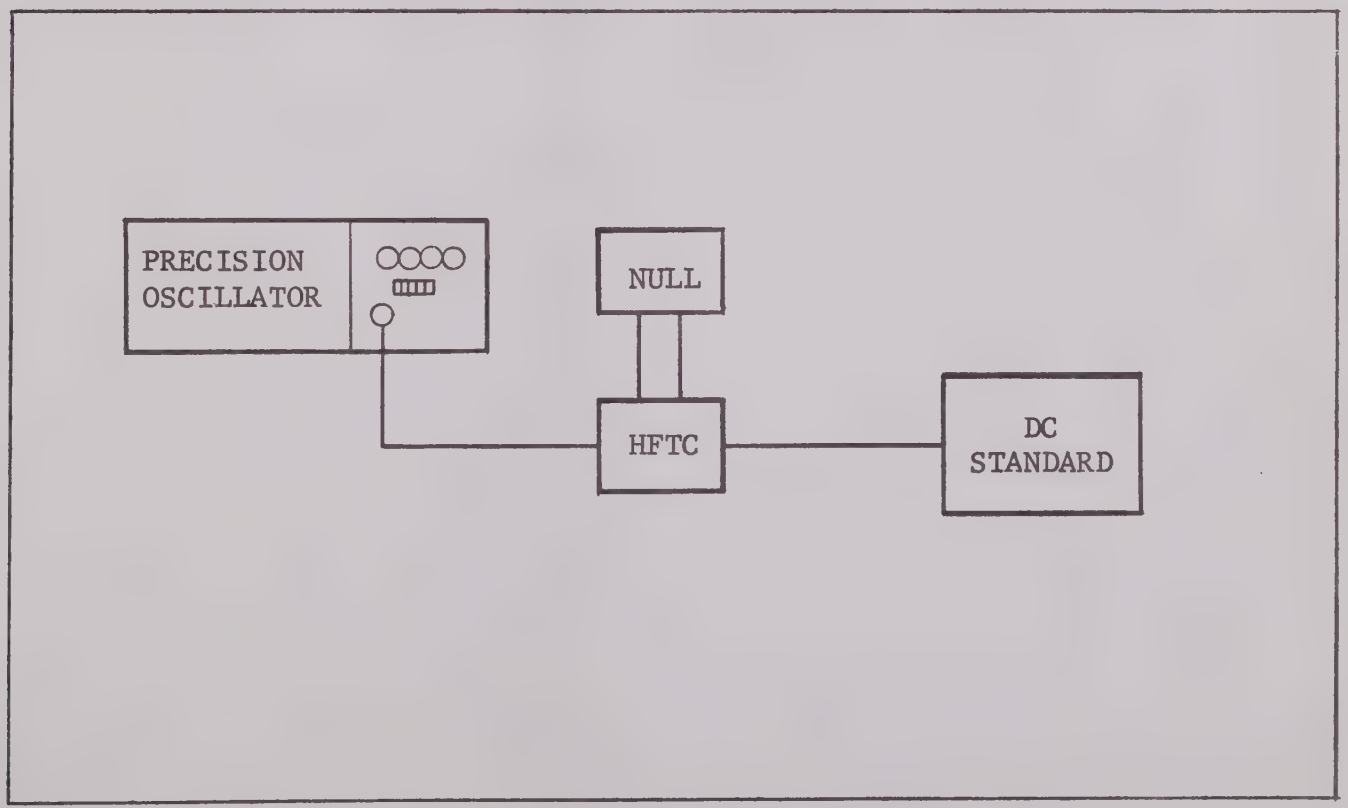



Figure 4-2. Frequency Response Setup

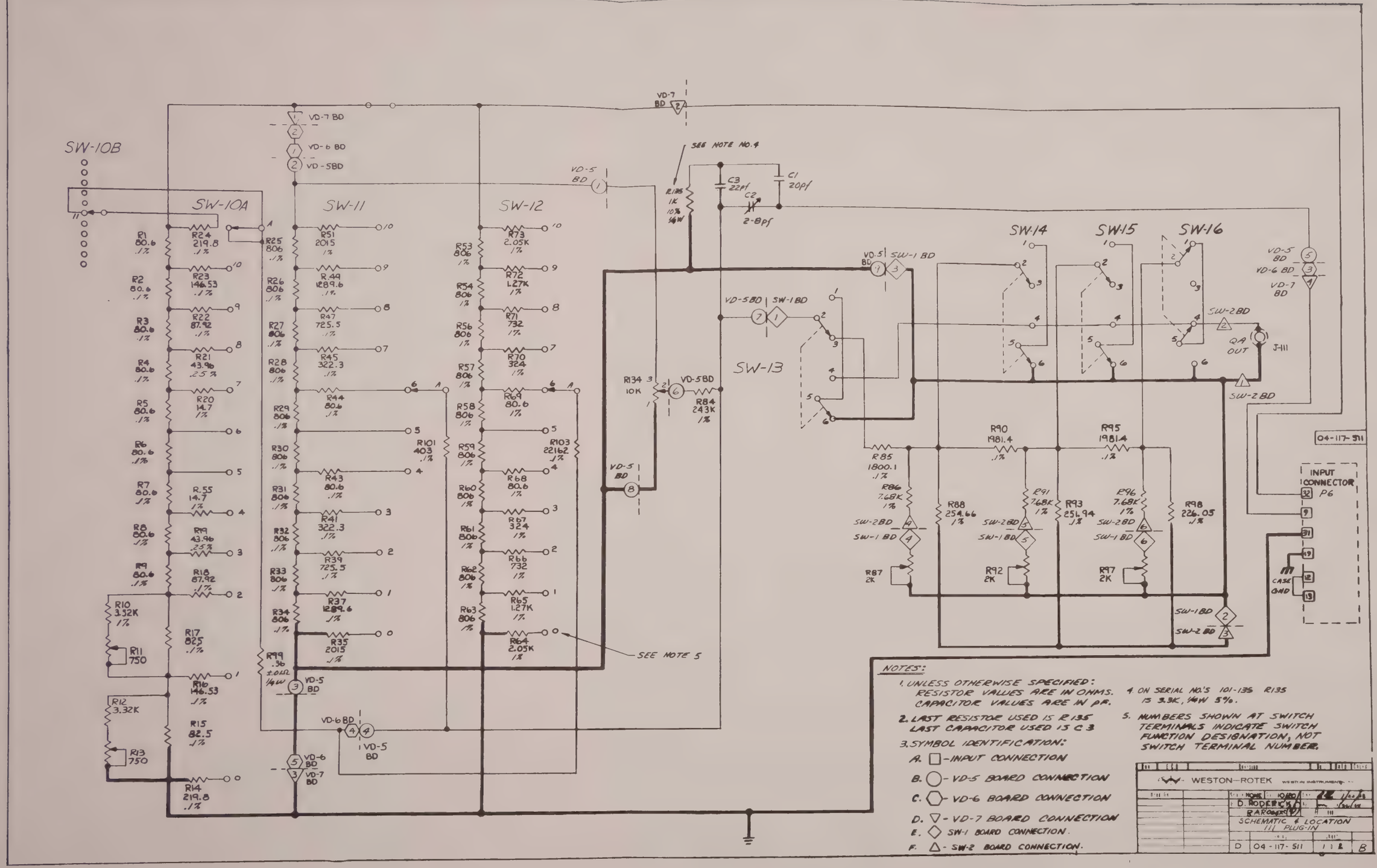
# SECTION 5

## CIRCUIT AND LOCATION DIAGRAMS

This section contains the overall schematic and location diagrams for the Model 111 Voltage Divider. The schematic is an overall schematic of the plug-in, and when used in conjunction with the Theory of Operation (Section 3.), should aid in understanding full operation of the plug-in.

Following is a list of the diagrams included in this section:

| Number | Title |
|---|---|
| 04-117-511-1 | Schematic, 111 Plug-In |
| 04-117-511-2 | Location, 111 Plug-In |




NOTES:

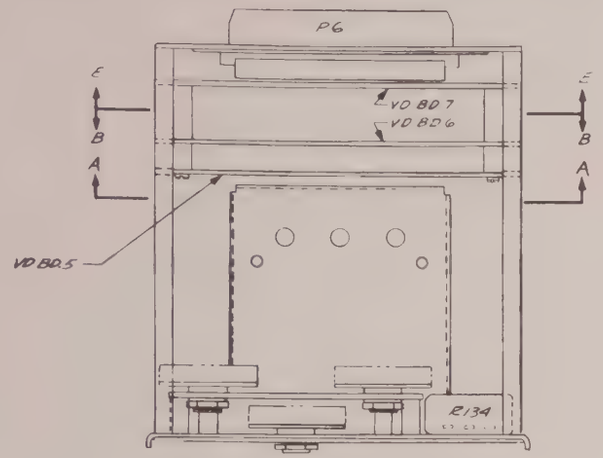
1. UNLESS OTHERWISE SPECIFIED: RESISTOR VALUES ARE IN OHMS. CAPACITOR VALUES ARE IN pf.
2. LAST RESISTOR USED IS R135 LAST CAPACITOR USED IS C3
3. SYMBOL IDENTIFICATION:
   - A. □ - INPUT CONNECTION
   - B. ○ - VD-5 BOARD CONNECTION
   - C. ⬡ - VD-6 BOARD CONNECTION
   - D. ▽ - VD-7 BOARD CONNECTION
   - E. ◇ - SW-1 BOARD CONNECTION.
   - F. △ - SW-2 BOARD CONNECTION.
4. ON SERIAL NO'S 101-135 R135 IS 3.3K, 1/4W 5%.
5. NUMBERS SHOWN AT SWITCH TERMINALS INDICATE SWITCH FUNCTION DESIGNATION, NOT SWITCH TERMINAL NUMBER.

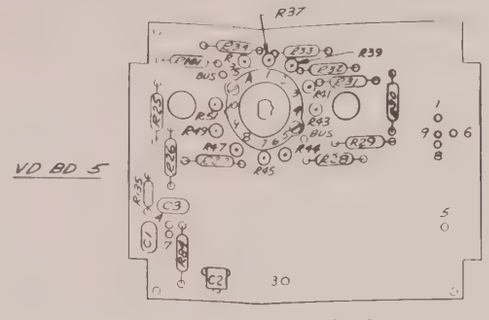
WESTON—ROTEK

D. RODERICK

SCHEMATIC & LOCATION
111 PLUG-IN

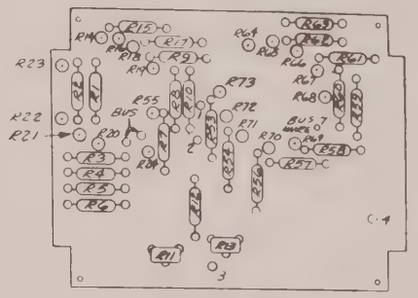
D | 04-117-511 | 1 & 2 | B



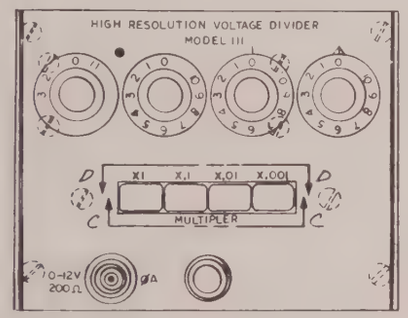

VD BD 5

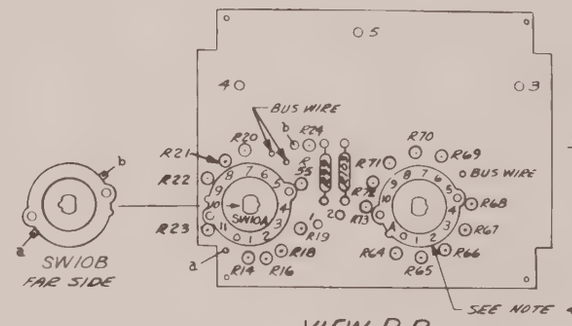
VIEW A-A




VD BD 7

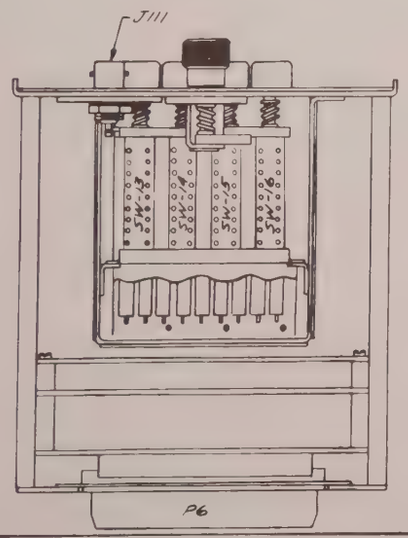
VIEW E-E

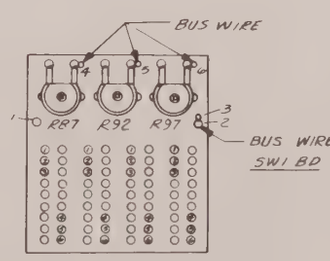


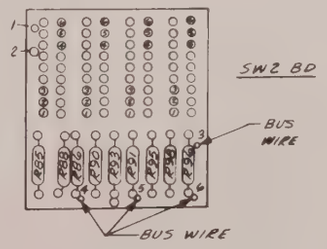

VD BD 6

VIEW B-B




VIEW D-D
SHOWN WITH COVER REMOVED




VIEW C-C
SHOWN WITH COVER REMOVED

UNLESS OTHERWISE SPECIFIED – DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±1/64
DECIMALS .X ±.03, .XX ±.01, .XXX ±.005
ANGLES ± 1/2° BENDS 90°
FABRICATE PER SPEC 89-002-000

MATERIAL –

APPEARANCE –

FINISH –

NEXT ASSY | REF SPEC'S

APPLICATION

CONTRACT

| AUTHENTICATION | DATE |
|---|---|
| DR | 11/18/68 |
| CHK | |
| REVIEW | |
| ENGR | 1/29/69 |
| APPD | 1/31/69 |

WESTON – ROTER

REF B M NONE

WESTON INSTRUMENTS, INC.
LEXINGTON DIVISION LEXINGTON MASS

SCHEMATIC & LOCATION
111 PLUG-IN

| SIZE | CODE IDENT NO. | DRAWING NO. |
|---|---|---|
| D | 11842 | 04-117-511-B |

SCALE NONE | UNIT WT | SHEET 2 OF 2

04-117-511

# SECTION 6

## REPLACEABLE PARTS

This section contains ordering information for replacement parts listed by assembly and model. Where manufacturer and type are not given (designated by **), parts may be ordered directly from Weston-Lexington. These parts should be identified by Weston-Lexington part number; the instrument model number and serial number should also be specified.

Following is a list of assemblies included in this section:


| Name | Page |
|---|---|
| Main Assembly | 6-2 |
| Switch Board 1 | 6-3 |
| Switch Board 2 | 6-4 |
| Voltage Divider Board 5 | 6-5 |
| Voltage Divider Board 6 | 6-6 |
| Voltage Divider Board 7 | 6-7 |

MAIN ASSEMBLY 04-117-511

| REFERENCE DESIGNATION | DESCRIPTION | W-L PART NO | MANUFACTURER | MFR. TYPE |
|---|---|---|---|---|
| | Panel, Front | 08-117-161 | Weston | -- |
| | Knob, Extractor | 03-117-200 | Weston | -- |
| | Latch, Panel | 07-117-377 | ** | -- |
| | Insulator, Connector BNC | 08-117-366 | Weston | -- |
| | Plate, Rear | 03-117-367 | Weston | -- |
| | Knob, Front Panel | 08-117-372-1 | ** | |
| | Knob, Front Panel | 08-117-372-5 | ** | |
| P6 | Connector, Male, 32 Pin | 29-033-232 | Amphenol | 26-4100-32P |
| J111 | Connector, BNC Receptacle | 29-057-001 | Amphenol | 31-105 |
| SW10 | Switch, Detent & Shaft | 34-063-999-9 | ** | -- |
| SW12 | Switch, Detent & Shaft | 34-063-999-10 | ** | -- |
| SW11 | Switch, Detent & Shaft | 34-063-999-11 | ** | -- |
| R134 | Resistor, Variable, 10K | 40-419-001 | Allen-Bradley | Type J |

SWITCH BOARD 1 04-117-511

| REFERENCE DESIGNATION | DESCRIPTION | W-L PART NO | MANUFACTURER | MFR. TYPE |
|---|---|---|---|---|
| SW13,14,15,16 | Switch, Pushbutton, 6 Pole, 12 Pos. | 34-074-001 | ** | -- |
| R87,92,97 | Resistor, Variable, 2K | 40-421-001 | Mallory | MTC23L4 |

SWITCH BOARD 2 04-117-511

| REFERENCE DESIGNATION | DESCRIPTION | W-L PART NO | MANUFACTURER | MFR. TYPE |
|---|---|---|---|---|
| R86,91,96 | Resistor, Film, 7.68K, 1W, 1% | 40-002-076 | IRC | CEC |
| R98 | Resistor, Film, 226.05Ω, 1W, 0.1% | 40-016-142 | IRC | CEC |
| R93 | Resistor, Film, 251.94Ω, 1W, 0.1% | 40-016-143 | IRC | CEC |
| R88 | Resistor, Film, 254.66Ω, 1W, 0.1% | 40-016-144 | IRC | CEC |
| R85 | Resistor, Film, 1800.1Ω, 1W, 0.1% | 40-016-158 | IRC | CEC |
| R90,95 | Resistor, Film, 1981.4Ω, 1W, 0.1% | 40-016-160 | IRC | CEC |

VOLTAGE DIVIDER BOARD 5 04-117-511

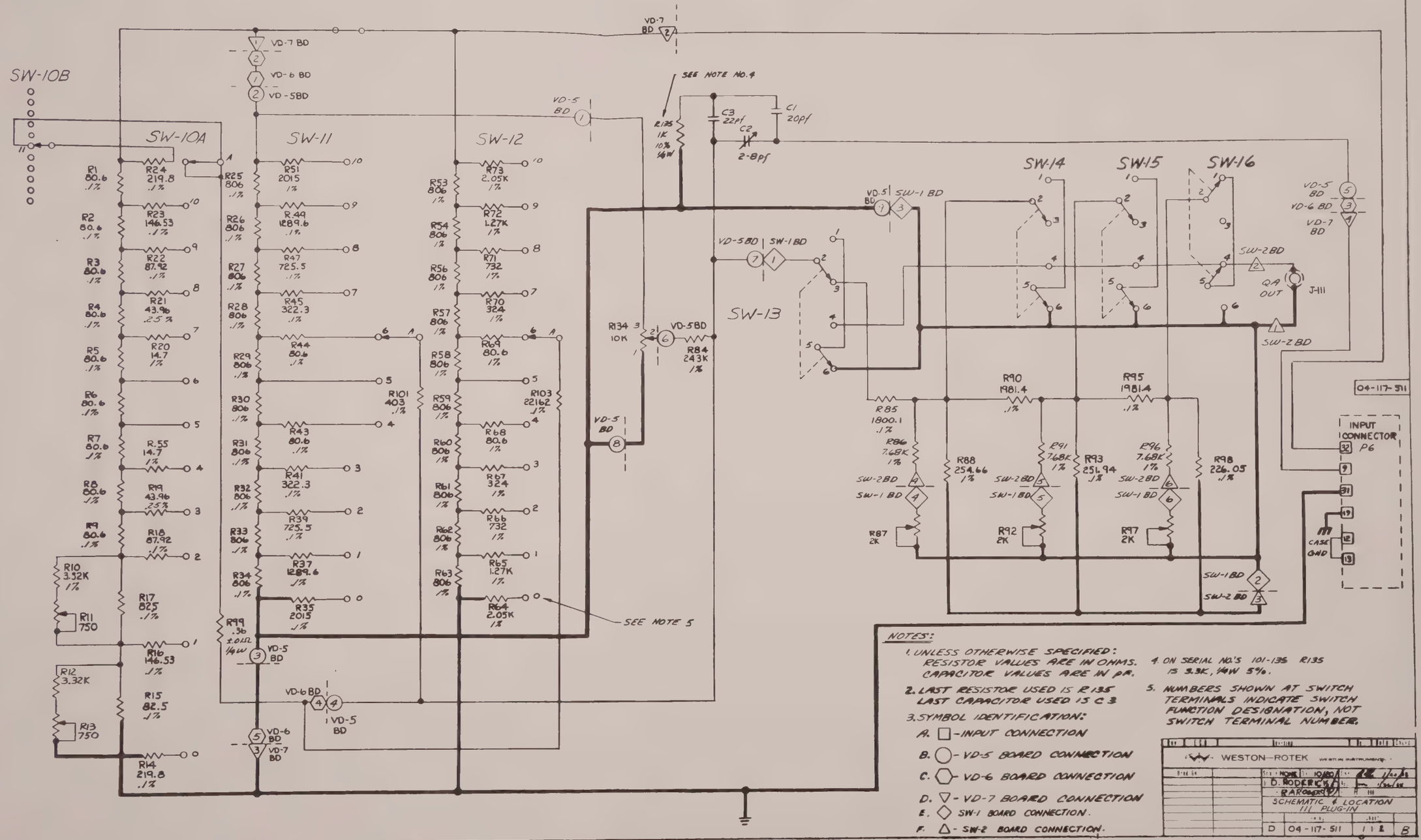
| REFERENCE DESIGNATION | DESCRIPTION | W-L PART NO | MANUFACTURER | MFR. TYPE |
|---|---|---|---|---|
| SW11 | Switch, Wafer, 1 Pole, 11 Pos. Shtg. | 34-063-207 | CTS | 212 |
| R85 | Resistor, Film, 243K, 1W, 1% | 40-002-112 | IRC | CEC |
| R135 | Resistor, Film, 1K, .25W, 10% | 40-012-001 | Allen-Bradley | CB |
| R43,44 | Resistor, Film, 80.6Ω, 1W, 0.1% | 40-016-024 | IRC | CEC |
| R25,26,27,28,29,30, 31,32,33,34 | Resistor, Film, 806Ω, 1W, 0.1% | 40-016-048 | IRC | CEC |
| R35,51 | Resistor, Film, 2015Ω, 1W, 0.1% | 40-016-054 | IRC | CEC |
| R37,49 | Resistor, Film, 1289.6Ω, 1W, 0.1% | 40-016-058 | IRC | CEC |
| R41,45 | Resistor, Film, 322.3Ω, 1W, 0.1% | 40-016-145 | IRC | CEC |
| R101 | Resistor, Film, 403Ω, 1W, 0.1% | 40-016-147 | IRC | CEC |
| R39,47 | Resistor, Film, 725.5Ω, 1W, 0.1% | 40-016-153 | IRC | CEC |
| C1 | Capacitor, Mica, 20pf, 300V | 45-001-003 | Electro-Motive | DM15C |
| C3 | Capacitor, Mica, 22pf, 300V | 45-002-002 | Electro-Motive | DM15E |
| C2 | Capacitor, Variable, 2-8pf | 45-504-002 | Erie | 538 |

VOLTAGE DIVIDER BOARD 6 04-117-511

| REFERENCE DESIGNATION | DESCRIPTION | W-L PART NO | MANUFACTURER | MFR. TYPE |
|---|---|---|---|---|
| SW10 | Switch, Wafer, 1 Pole, 11 Pos., Shtg. | 34-063-007 | CTS | 212 |
| SW12 | Switch, Wafer, 1 Pole, 11 Pos., Shtg. | 34-063-207 | CTS | 212 |
| R103 | Resistor, Film, 22162Ω, 1W, 0.1% | 40-016-163 | IRC | CEC |
| R99 | Resistor, WW, .36Ω, .25W, .01% | 40-147-003 | Daven | 1274 |

VOLTAGE DIVIDER BOARD 7 04-117-511

| REFERENCE DESIGNATION | DESCRIPTION | W-L PART NO | MANUFACTURER | MFR. TYPE |
|---|---|---|---|---|
| R30,55 | Resistor, Film, 14.7Ω, 1W, 1% | 40-002-008 | IRC | CEC |
| R68,69 | Resistor, Film, 80.6Ω, 1W, 1% | 40-002-026 | IRC | CEC |
| R67,70 | Resistor, Film, 324Ω, 1W, 1% | 40-002-040 | IRC | CEC |
| R66,71 | Resistor, Film, 732Ω, 1W, 1% | 40-002-047 | IRC | CEC |
| R53,54,55,56,57,58, 59,60,61,62,63 | Resistor, Film, 806Ω, 1W, 1% | 40-002-048 | IRC | CEC |
| R65,72 | Resistor, Film, 1.27KΩ, 1W, 1% | 40-002-056 | IRC | CEC |
| R64,73 | Resistor, Film, 2.05KΩ, 1W, 1% | 40-002-062 | IRC | CEC |
| R10,12 | Resistor, Film, 3.32KΩ, 1W, 1% | 40-002-067 | IRC | CEC |
| R16,23 | Resistor, Film, 146.53Ω, 1W, 0.1% | 40-016-022 | IRC | CEC |
| R1-9 | Resistor, Film, 80.6Ω, 1W, 0.1% | 40-016-024 | IRC | CEC |
| R15,17 | Resistor, Film, 82.5Ω, 1W, 0.1% | 40-016-025 | IRC | CEC |
| R18,22 | Resistor, Film, 87.93Ω, 1W, 0.1% | 40-016-026 | IRC | CEC |
| R14,24 | Resistor, Film, 219.8Ω, 1W, 0.1% | 40-016-032 | IRC | CEC |
| R19,21 | Resistor, Film, 43.96Ω, 1W, 0.25% | 40-017-001 | IRC | CEC |
| R11,13 | Resistor, Variable, 750Ω | 40-420-001 | Mallory | MTC751L1 |




NOTES:

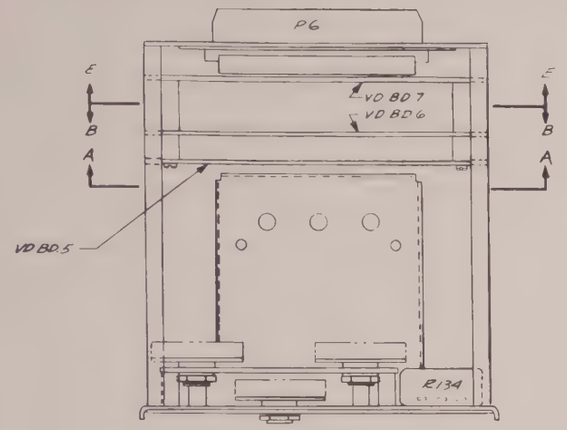
1. UNLESS OTHERWISE SPECIFIED: RESISTOR VALUES ARE IN OHMS. CAPACITOR VALUES ARE IN pF.
2. LAST RESISTOR USED IS R135 LAST CAPACITOR USED IS C 3
3. SYMBOL IDENTIFICATION:
   - A. □ - INPUT CONNECTION
   - B. ○ - VD-5 BOARD CONNECTION
   - C. ⬡ - VD-6 BOARD CONNECTION
   - D. ▽ - VD-7 BOARD CONNECTION
   - E. ◇ - SW-1 BOARD CONNECTION.
   - F. △ - SW-2 BOARD CONNECTION.
4. ON SERIAL NO'S 101-135 R135 IS 3.3K, 1/4W 5%.
5. NUMBERS SHOWN AT SWITCH TERMINALS INDICATE SWITCH FUNCTION DESIGNATION, NOT SWITCH TERMINAL NUMBER.

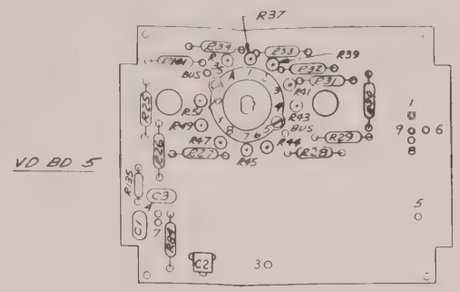
WESTON—ROTEK

D. RODERICK

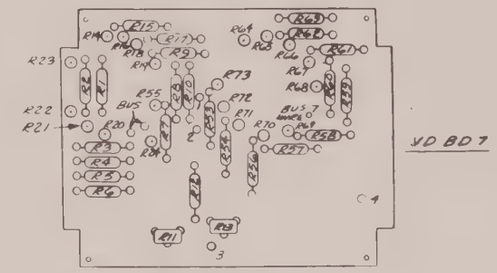
SCHEMATIC & LOCATION
111 PLUG-IN

D | 04-117-511 | 1 1 2 | B

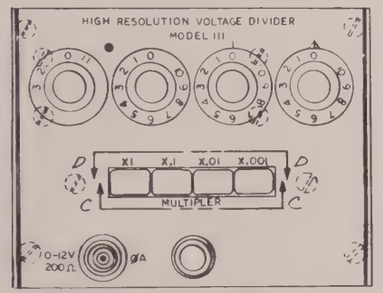


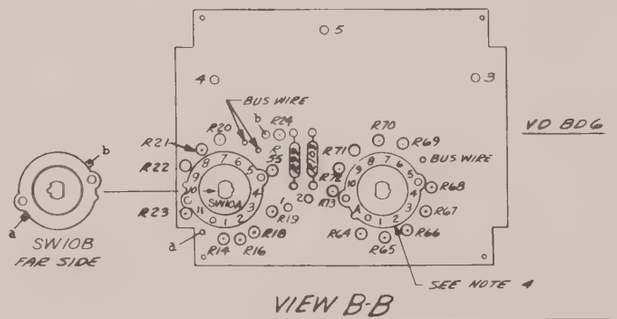




VIEW A-A

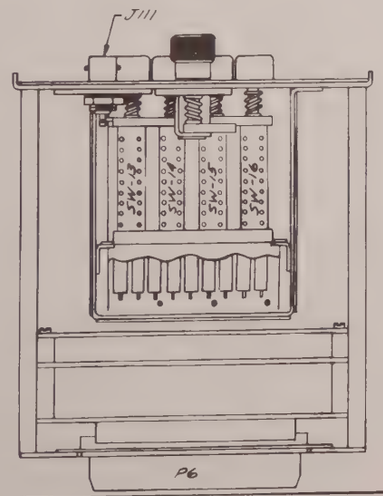


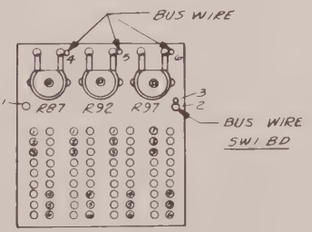

VIEW E-E



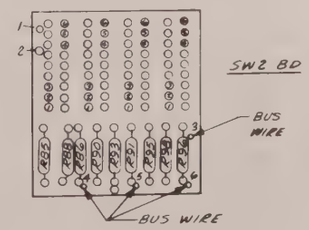




VIEW B-B




VIEW D-D
SHOWN WITH COVER REMOVED




VIEW C-C
SHOWN WITH COVER REMOVED

| | | | | | |
|---|---|---|---|---|---|
| | | UNLESS OTHERWISE SPECIFIED – DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS .X ±.03, .XX ±.01, .XXX ±.005 ANGLES ±1/2° BENDS 90° FABRICATE PER SPEC 89-002-000 | CONTRACT | | REF B M NONE |
| | | | AUTHENTICATION | DATE | WESTON INSTRUMENTS INC. LEXINGTON DIVISION LEXINGTON MASS |
| | | | DRN | 11/8/67 | SCHEMATIC & LOCATION III PLUG-IN |
| | | | CHK | | |
| | | | REVIEW | | |
| | | | ENGR | 1/24/68 | |
| | | MATERIAL – | APPD | 1/24/68 | |
| | | APPEARANCE – | WESTON – ROTEK | | SIZE D CODE IDENT NO 11842 DRAWING NO. 04-117-511-B |
| | | FINISH – | 19 | | SCALE NONE UNIT WT SHEET 2 OF 2 |
| NEXT ASSY | REF SPEC'S | | | | |
| APPLICATION | | | | | |

04-117-511

Serial Number_____

RECEIVED
APR 01 1969
FRENCH RD.
CALIBRATION LAB

TEMPORARY
OPERATING AND SERVICE MANUAL

MODEL DVO-102

DECADE VARIABLE OSCILLATOR

RECEIVED
APR 01 1969
FRENCH RD
CALIBRATION LAB

Serial Numbers 101 -

First Edition (12/1/68)

WESTON INSTRUMENTS, INC.
Weston-Lexington Division
17 Hartwell Avenue
Lexington, Massachusetts 02173

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# W A R R A N T Y

Weston-Lexington warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this Warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose, and to replace any defective parts thereof. This Warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon out examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed to the customer. In this case, an estimate will be submitted before the work is started.

IF ANY FAULT DEVELOPS, THE FOLLOWING STEPS SHOULD BE TAKEN:

1. Notify us giving full details of the difficulty; include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.
2. On receipt of shipping instructions, forward the instrument prepaid to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

# SECTION I

# DESCRIPTION AND SPECIFICATIONS

## 1.1. GENERAL DESCRIPTION

The Weston-Lexington Decade Variable Oscillator Model DVO-102 is a double-integrator, phase-shift oscillator covering a frequency range from 10Hz to 111kHz. The oscillator amplitude of 12.11V rms is held constant to ±0.01% up to 50kHz and waveform purity of 50ppm is typical over the operating frequency range. The DVO may be used as a two-phase oscillator with phase A defined as the reference phase and with phase B lagging phase A by 90° ±0.1° at mid-band. All circuits are fully isolated from the outer case and can be made fully floating with respect to powerline ground by means of a switch provided on the rear panel.

Switched decade-potentiometers control the oscillating frequency. Frequencies from 10Hz to 111kHz may be continuously selected by means of three 11 position rotary switches with a multi-turn over-ranging vernier for the fourth significant digit, plus a 4 position range switch. Frequency accuracy (0.5% of setting) and phase B accuracy over the frequency range are superior to the characteristics available with continuous-tuning analog potentiometers. Furthermore, frequency settings may be precisely repeated in production and testing applications.

Fixed amplitude front-panel outputs are provided for each phase at a low output impedance and are capable of driving a wide variety of external inductive or resistive dividers without additional amplification or impedance buffering. Plug-in modules provide versatility and permit adding further capabilities to handle

new requirements at a later date. A number of plug-ins are listed in Section 1.3. The Weston-Lexington Model 108 Auxiliary Plug-in, or any other plug-ins listed in Section 1.3., are required to provide internal connections for basic unit operation.

## 1.2. SPECIFICATIONS

| | |
|---|---|
| SETTINGS: | 10.000Hz to 111.200kHz continuous coverage in 4 decade ranges with in-line readout and illuminated decimal points. |
| CONTROLS: | (a) Three decade frequency-selection switches, with 10% overranging on each decade.<br>(b) Fourth frequency-selection decade provided by multi-turn vernier, with 100% overranging.<br>(c) Four-position range-multiplier switch. |
| FREQUENCY CALIBRATION ACCURACY: | ±0.5% of setting (entire frequency range). |
| RESOLUTION: | Electrical vernier permits frequency output to be set to within ±0.01% when using an external counter, or Weston-Lexington series 300 computing frequency counters. |
| FREQUENCY STABILITY VS. TIME: | ±0.01%/hr. 100Hz - 110kHz maximum, at constant temperature and line voltage.<br>±0.02%/hr. 10Hz - 110Hz maximum, at constant temperature and line voltage. |
| FREQUENCY STABILITY VS. TEMPERATURE: | ±0.01%/°C maximum. 100Hz - 110kHz<br>±0.02%/°C maximum. 10Hz - 110Hz |
| FREQUENCY STABILITY VS. LINE: | ±0.005% maximum for 10% line variation. |
| FREQUENCY STABILITY VS. LOAD: | ± .01% below 10kHz<br>± .02% 10kHz to 110kHz<br>} no load to full load. |

VOLTAGE ØA & ØB:

12.11 volts rms nominal supplied at low impedance to:
(a) Plug-in module
(b) Front Panel fixed outputs
(c) Rear Panel fixed outputs

Note: The nominal voltage may be varied by using some types of plug-ins. Refer to plug-in specifications for further information.

RESISTIVE LOAD:

60ma rms per phase maximum for specified performance. Current available from fixed output is reduced by plug-in requirements. Refer to plug-in specifications for further information.

MAXIMUM CAPACITANCE LOADING FOR SPECIFIED PERFORMANCE, EITHER PHASE:

| | | |
|---|---|---|
| 500pf | (10Hz - 11kHz) | Parallel $R_L$ 1KΩ or lower |
| 1000pf | (10kHz - 110kHz) | |
| 300pf | (10Hz - 11kHz) | Parallel $R_L$ greater than 1KΩ |
| 600pf | (10kHz - 110kHz) | |

RATIO TRANSFORMER LOADING:

Both ØA and ØB outputs capable of driving most commercial ratio transformers.

VOLTAGE ACCURACY AT 400Hz and 25°C:

ØA ±0.05%
ØB ±.2%

FREQUENCY RESPONSE referred to 400Hz, ØA

ØA:

| | | |
|---|---|---|
| ±0.005% | (.005db) | 50Hz - 11kHz (option 08) |
| ±0.01% | (.001db) | 20Hz - 50kHz |
| ±0.02% | (.002db) | 10Hz - 20Hz and 50kHz - 100kHz (add 0.005% to 110kHz) |

ØB:

| | | |
|---|---|---|
| ±0.2% | (0.02db) | 100Hz - 11kHz |
| ±0.5% | (0.05db) | 10Hz - 110Hz |
| ±2% | (0.2db) | 10kHz - 110kHz |

HARMONIC DISTORTION:

ØA:

| | |
|---|---|
| 0.005% Max. | 50Hz - 60Hz and 380Hz - 1.1kHz on X100 range |
| 0.01% Max. | 20Hz - 50kHz |
| 0.02% Max. | 10Hz - 20Hz and 50kHz - 110kHz |

ØB: Twice the values for ØA.

| | | |
|---|---|---|
| AMPLITUDE STABILITY VS. TIME AT CONSTANT TEMPERATURE & LINE: | ØA: | 8 hours: ±0.01% max.<br>One month: ±0.05% max.<br>5-10 minutes: ±0.002% typical. |
| | ØB: | Stability figures typically twice those for ØA. |
| AMPLITUDE STABILITY VS. TEMPERATURE: | ØA: | ±0.01%/°C, with ±0.005%/°C available as option (See internal options). |
| | ØB: | ±0.02%/°C. |
| AMPLITUDE STABILITY VS. LINE: | ØA: | ±0.005% Max. for 10% line variation. |
| CYCLE-TO-CYCLE STABILITY: ØA and ØB | | Less than ±0.01% including short-term noise. |
| TUNING TRANSIENTS: | | Amplitude deviations are typically less than 2% (0.2db) for a frequency dial change. |
| OUTPUT IMPEDANCE: | | |
| 12 volt front panel fixed outputs | ØA:<br>ØB: | 25 milliohms series .5 microhenries<br>400 milliohms series 2 microhenries |
| 12 volt rear connector fixed outputs | ØA:<br>ØB: | 400 milliohms series 1 microhenry<br>600 milliohms series 3 microhenries |
| | ØA: | Amplitude will change ±0.02% above 50kHz for a 0 to full load change on ØB. |
| | ØB: | Amplitude will change 0.4% at 10Hz, and 0.2% above 30Hz for 0 to full load change on ØA. |
| QUADRATURE PHASE ACCURACY: | | ±0.1° (400Hz - 11kHz)<br>±1° (10kHz - 110kHz) |
| | | $\pm .1° \times \frac{400}{f\ (Hz)}$ (10Hz - 400Hz) |

| | |
|---|---|
| LINE FREQUENCY BEAT: | Less than ±0.01% near line frequency, or multiples for 110 volt operation, and ±0.02% for 220 volt line. |
| DC COMPONENT: | Capacitor-coupled output. |
| OVERLOAD PROTECTION: | All outputs may be continuously overloaded or short-circuited without damage. The oscillator meets all performance specifications after the overload is removed, except full specified amplitude and frequency stability performance requires several minutes for internal temperature restabilization. |
| FLOATING OPERATION: | A rear panel switch is provided which disconnects signal ground from the chassis to allow floating operation. |
| EXTERNAL MODULATION: | A rear-panel switch is provided to allow amplitude modulation by slowly varying control signals. |
| REAR PANEL CONNECTOR SIGNALS: | (a) 12.11v rms fixed, ØA & ØB outputs.<br>(b) Plug-in attenuator outputs (most plug-ins)<br>(c) External modulation input.<br>(d) Range switch position contact-closure outputs.<br>(e) External synchronization input (option 05) |
| TEMPERATURE RANGE FOR SPECIFIED PERFORMANCE: | 15° - 40°C. |
| OPERATING TEMPERATURE RANGE: | 0° - 52°C. |
| WARM-UP TIME: | 30 minutes maximum for stated stability. |

| | |
|---|---|
| POWER REQUIREMENTS: | 105-130 or 210-260 volts single phase; 47-66Hz; 50 watts. |
| DIMENSIONS AND WEIGHT: | 5-1/4" high, 16-7/8" wide, 15-3/4" deep, 30 lbs. |

## INTERNAL OPTIONS

| | |
|---|---|
| 01 | ±0.05%/°C maximum, ØA amplitude variation versus temperature. |
| 05 | External synchronization - 1 volt rms will lock oscillator over a ±0.5% frequency range. |
| 07 | Guard Driver and rear-panel connector which allows long leads to be used on attenuator ØA output without affecting frequency response. The Guard Driver is capable of driving up to 1000pf at 100kHz. |
| 08 | ±0.005% (0.0005db) frequency response from 50Hz to 10kHz. |

## 1.3. PLUG-IN MODULES AVAILABLE

| MODEL NO. | DESCRIPTION |
|---|---|
| 108 | Auxiliary Plug-in; provides internal connections necessary for operation. |
| 109 | Single phase divider with moderate accuracy and resolution. |
| 110 | Two phase divider, same as 109 except 2 phases. |
| 111 | High resolution, high accuracy divider (single phase) |
| 114 | 10 volt standardizer used to set "zero" impedance output level to exactly 10 volts for driving ratio transformers, etc. |

## 1.4. ACCESSORIES AVAILABLE

| W-L PART NO. | DESCRIPTION |
|---|---|
| 03-117-280-1 | Rack mounting ears (2 Req'd) |
| 29-032-229 | Connector, 29 pin female, for use with rear panel output connector |
| 13-117-063 | Printed circuit board extender |
| 02-100-178 | Tilt stand assembly |
| 02-100-174 | Stacking bracket; clamps companion equipment on top of DVO-102 case to conserve bench space. |
| 02-117-307 | 10:1 Attenuator box for use with Divider Plug-Ins; 50Ω output impedance |
| 02-117-308 | 600Ω Impedance Adaptor box for use with Divider Plug-Ins |
| 03-100-183 | Slide Mounting Spacer for Johnathan 18" Slides (2 Req'd) |

## 1.5. COMPANION EQUIPMENT

| MODEL NO. | |
|---|---|
| HVA-120 | Hectovolt Amplifier; provides high level outputs to 120 volts rms at 50 ma, dc to 100kHz, with frequency response, distortion and stability comparable to the series 100 Precision Oscillators. |
| DRO-300 Series | Computing-type Frequency Counters; displays frequency within .01% accuracy, up dated 5 times per second even at 10Hz. Provides an accurate frequency source which is rapidly adjustable when used with series 100 Precision Oscillators. |
| 212H/620 | NBS test-reportable Peak Comarator and Attenuator may be used for accurate adjustment of output level and for midband linearity calibration, as an alternative to time-consuming thermal transfer methods. |

## 1.6. RELATED APPLICATION NOTES

The following Application Notes are available from your Weston-Lexington sales representative:

1. USE OF MODEL 212H COMPARATOR WITH MODEL CVO-100 PRECISION OSCILLATOR (AN 10-67/212H-CVO-100/001)
   Describes the proper techniques which will provide the highest accuracies when the Model 212H AC-to-DC Peak Comparator is used in conjunction with the series 100 Precision Oscillators.

2. SIMPLIFIED FREQUENCY RESPONSE MEASUREMENTS (AN 1-68/300/007)
   Describes how recently designed and commercially available equipment can measure frequency response of four terminal networks (transfer characteristics) to within ±0.1% over a wide frequency range with semi-skilled personnel.

3. AN ABSOLUTE 10 VOLT AC REFERENCE TO 100 kHz (AN 10-67/CVO-100/002)
   Describes how a Weston Precision Oscillator with the Model 114 Voltage Standardizer Plug-In and popular ratio transformers provide a low voltage absolute calibration system with excellent wide band performance to 100 kHz, at low cost.

4. PHASE ANGLE GENERATION USING CVO-100 (AN 12-67/CVO-100/004)
   Describes how a Weston Precision Oscillator may be used as a phase standard to generate angles from 0° to 360° over a relatively broad band of frequencies to accuracies of better than 0.1°.

5. MEASURING TOTAL HARMONIC DISTORTION OF LESS THAN 0.01% (AN 4-68/CVO-100/010).
   Describes how the use of twin-T filters and wave analyzers offer a means for making accurate distortion measurements of very low distortion signals which would have been beyond the capabilities of commercially available equipment.

6. NEW CONCEPT IN LOW FREQUENCY COUNTING (AN 1-68/300/005)
   Normal frequency counters measure the number of times a periodic signal passes through a reference voltage in a unit time. This paper describes how it is possible to compute and display directly the frequency of a low frequency signal with high resolution, high accuracy and high speed based on a periodic measurement.

# SECTION 2

# INSTALLATION

## 2.1. INITIAL INSPECTION

This instrument has been carefully inspected both mechanically and electrically before shipment and should be in perfect operating condition and free from all scratches or mars. It should be inspected for physical damage caused in transit to confirm this fact.

## 2.2. POWER REQUIREMENTS

The Model DVO-102 may be operated from any source of 115 volts 50 to 60Hz. Power requirements are approximately 80VA. If 230 volts is to be used, refer to the block diagram in Section 6 for wiring changes. The unit is supplied with a three-conductor power cable such that the instrument case is normally grounded when the cable is plugged into the appropriate receptacle. The ground wire is the off-set pin on the power cable.

## 2.3. FAN OPERATION

Although the Model DVO-102 is fully transistorized, it uses forced-air cooling for higher reliability and longer operating life. Because of this fact, care should be taken not to block the fan intake or restrict air circulation. The fan filter should be cleaned regularly to assure a long, trouble-free life. The instrument, however, should not be operated where the ambient temperature is in excess of 52°C (125.6°F).

## 2.4. RACK/BENCH INSTALLATION

The Model DVO-102 is shipped as a bench-mounted instrument. An accessory rack-mounting kit is available which includes the necessary instructions for installation.

# SECTION 3

# OPERATION

## 3.1. INTRODUCTION

All instructions and information necessary for the operation of the Model DVO-102 is contained in this section.

## 3.2. CONTROLS AND CONNECTORS

The front and rear panel controls and connectors are identified and illustrated in Figures 3-1 and 3-2.

## 3.3. TURN-ON PROCEDURE

To turn on the Model DVO-102, proceed as follows:

a. Apply ac power to the Model DVO-102 by plugging in the three-conductor power cord supplied with the unit from the power input connector to a proper power receptacle.

b. Push power button: The button should illuminate when the unit is "on".

## 3.4. OPERATING INSTRUCTIONS

For normal operation, proceed as follows:

a. Set floating/grounded switch on rear panel to "grounded" position.

b. Set external modulation switch on rear panel to "off" position.

### 3.4.1. FREQUENCY SELECTION

To select a desired frequency, set the multiplier switch to the desired range, set the frequency decades and vernier to the appropriate positions. The actual frequency setting is indicated

by the in-line display and lighted decimal point.

3.4.2 AMPLITUDE CONTROLS

The signals are brought to the front-panel reference outputs at very low impedance and at a level of 12.11 volts rms. The signal voltage is also supplied to the plug-in module and rear output connectors at low impedance. (See manual on plug-in module used for further information and instructions).

3.4.3. FLOATING OPERATION

If it is desirable to connect the outer case of the Model DVO-102 to a point other than oscillator output low, set floating/grounded switch in the "FLOATING" position. (It is not recommended to drive the chassis at any frequency above 10Hz because of excessive beat). The voltage between chassis and circuit ground should not exceed 100 volts peak or dc.

3.4.4. EXTERNAL MODULATION

Set the external modulation switch on rear panel to the "EXT. MOD" position. The amplitude should drop to 1/2 its value when switch is in this position. The modulating input signal is connected between pins 4 (hi)and 8 (gnd) on the rear connector. The input impedance between pins 4 and 8 is 10K ohms. Set the oscillator to the desired carrier frequency (see Section 3.4.1.), and adjust the magnitude of the modulating signal for the required modulation. When high percentage modulation is required, it is recommended that the highest modulating frequency be limited to 1/5,000 to 1/10,000 of the carrier (oscillating) frequency. The maximum modulating signal required for 90% modulation will never exceed 5 volts peak-to-peak.

3.4.5. EXTERNAL SYNCHRONIZATION MODE (Option 05)

Set external synchronization switch to "EXT. SYNC." position. Check the fuse (1/32 amp). Connect the synchronizing

signal between pins 10 (hi) and 8 (gnd) on the rear connector. One volt rms into the 7.6K ohms input impedance is necessary for synchronization. Adjust the DVO frequency (Section 3.4.1.) to the synchronizing frequency and observe the Lissajous pattern between the two frequencies as shown in Figure 3-1 below:

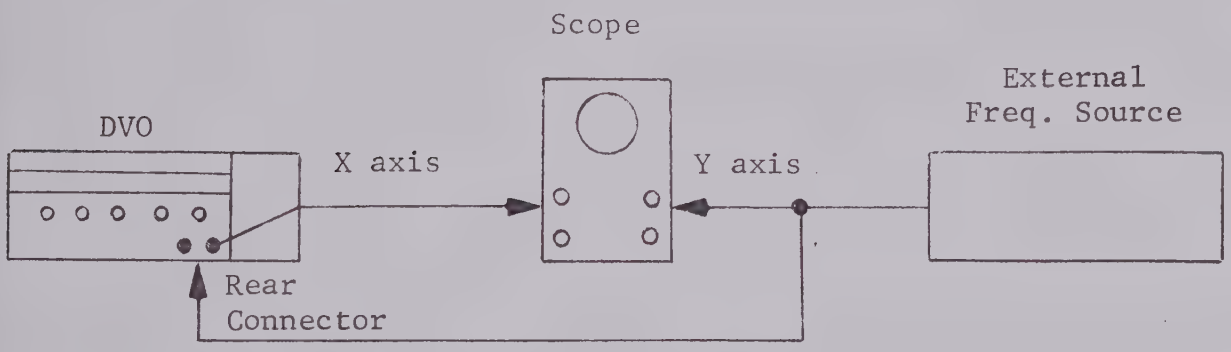
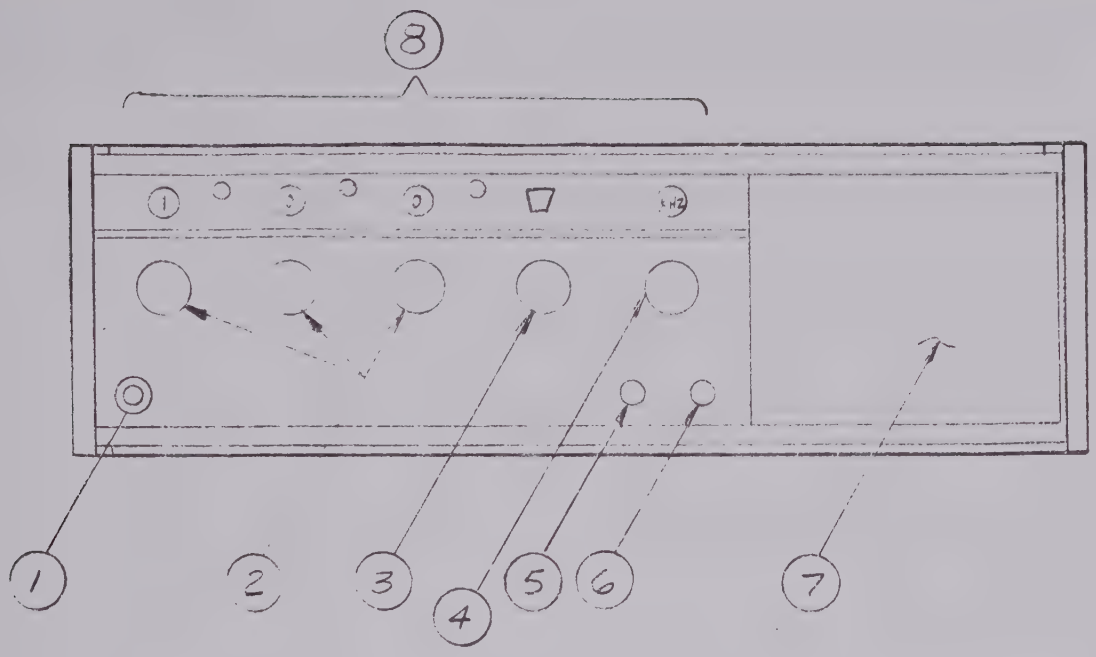



Figure 3-1

Test Circuit for External Synchronization

The oscillator is in synchronization when the Lissajous pattern stops rotating. The oscillator will remain in synchronization for a ±0.5% variation of the synchronizing input frequency.




1. POWER push button (internally lighted), applies operating power to the equipment.

2. FREQUENCY SETTING switched decades, set frequency within each multiplier range.

3. FREQUENCY VERNIER calibrated as a fourth frequency setting decade, provides extremely fine adjustment resolution.

4. FREQUENCY MULTIPLIER switch selects frequency range.

5. PHASE A OUTPUT (J4), main output of equipment.

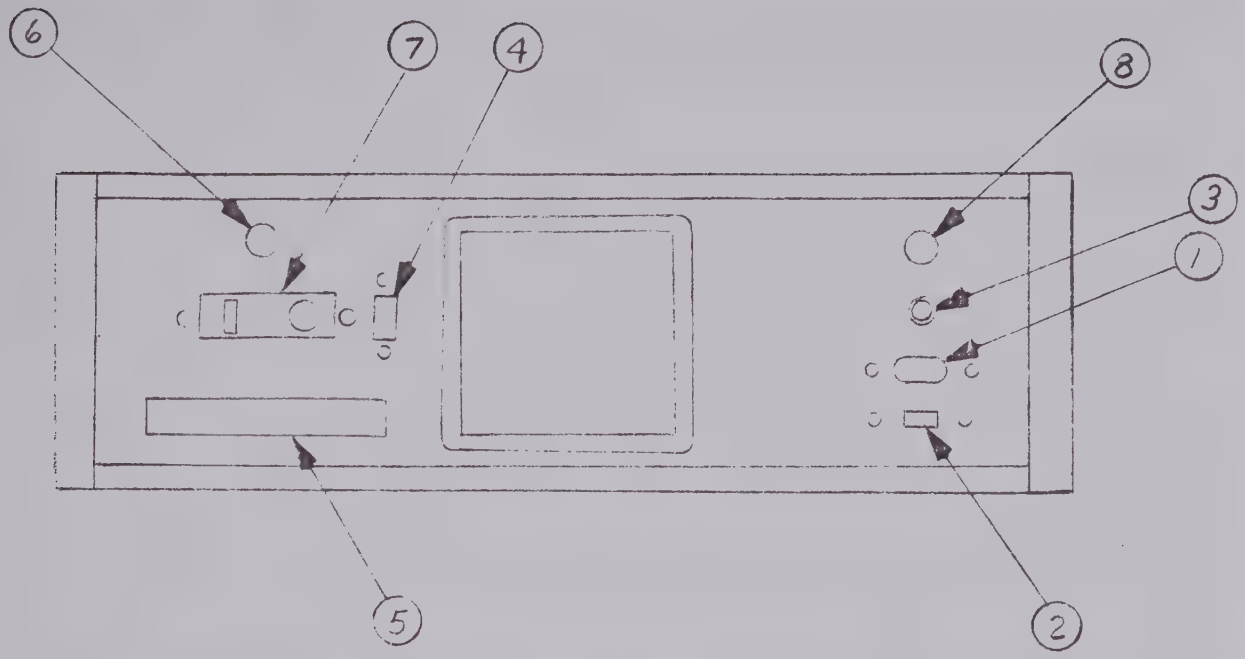
6. PHASE B OUTPUT (J5), lags phase A by 90°.

7. PLUG-IN CAVITY accepts plug-in modules.

8. IN-LINE DISPLAY indicates operating frequency, including lighted decimal point and units (Hz, kHz).

Figure 3-2

Front Panel Controls and Connectors




1. POWER INPUT connector (J2) accepts the power cord supplied with the instrument.

2. FLOATING/GROUNDED switch (S1) disconnects internal ground from chassis for floating operation.

3. MAIN UNIT FUSE protects internal circuits.

4. EXTERNAL MODULATION switch (S2) allows amplitude to be modulated by external signal.

5. MAIN REAR CONNECTOR (J1) provides plug-in outputs, ØA & ØB at "zero" output impedance, range switch position information.

6. PLUG-IN OUTPUT WITH DRIVEN GUARD (option 07) allows long leads to be used on attenuator ØA output without affecting frequency response.

7. EXTERNAL SYNCHRONIZATION SWITCH PLATE (option 05) provides external synchronization on main rear connector.

8. ACCESSORY POWER OUTLET (J7), provides power for accessory equipment, controlled by Oscillator on/off switch.

Figure 3-3

Rear Panel Controls and Connectors

## SECTION 4

## THEORY OF OPERATION

Figure 4-1 shows the dual-integrator oscillator configuration with the addition of the automatic phase-adjusting, amplitude-control feedback loop. Operational amplifiers A1 and A2, in conjunction with R2-C1 and R4-C2 respectively, constitute the integrators; with R2 = R4 and C1 = C2. The ganged decade potentiometers, represented by R1 and R3, provide accurate frequency variation; in practice, each of these potentiometers consists of three separate decade voltage dividers (Digital Control A, B) which are added together with the proper weighting through resistive summing networks at the input of each integrator. Capacitors C1 and C2 are switched in decade steps to provide 10:1 frequency ranging.

Each integrator furnishes approximately 90° of phase-shift. Operational amplifier A3 supplies the additional 180° to close the oscillating loop. Due to the fact that both A1 and A2 are finite, however, the total loop phase-shift is slightly less than 360°. The additional network from the output of A1 to the summing junction of A3 composed of R7 and R8 in series with the modulator M, supplies a phase-advance, make-up signal.

The current through R8 is in quadrature with the current through input resistor R5; both summing into inverting amplifier A3, so that for reasonable gains -- say 10,000 -- in A1 and A2, only a small signal is required at $E_4$ to swing the total feedback vector by the incremental phase-shift required for oscillation.

$E_4$ is determined by rectifying the output $E_2$ from amplified A2, and comparing the result with the potential of a precision zener reference at the input of integrator I as shown. Use of the

integrator supplies a typical gain of over 50,000 for the amplitude-controlling loop. Integrator output $E_5$ controls the modulator M, which in turn sets the magnitude of $E_4$, the incremental phase make-up signal.

Precision decade potentiometers represented by R1 and R3 control the frequency at which the loop oscillates by determining, in conjunction with R2-C1 and R4-C2, the frequency at which net loop gain is unit. R5 is equal to R6, so that inverter output $E_3$ has unity gain from the inverted input $E_2$. Hence net loop gain is unity at the frequency $f_o$ at which the absolute value of the (identical) integrator gains ($\frac{1}{2\pi f_o R_2 C_1}$ and $\frac{1}{2\pi f_o R_4 C_2}$) are equal to the (identical) attenuations of ganged decade potentiometers R1 and R3. Thus $E_1 = E_3$ as well, since the attenuation through R1 is exactly compensated by the gain through the integrator (R2-A1-C1). $E_2$ is taken as the main oscillator output. $E_1$ is used as the quadrature output for applications in which such an output is desirable -- gyro supplies, calibration of phase-sensitive voltmeters, phase meters, and similar measurements areas.

Integrator amplifiers A1 and A2 are stabilized at 6db/octave up to 150 kHz. The slop changes to 12 db/octave from about 150 kHz to within two octaves of crossover which occurs at about 5 MHz, changing to 6 db/octave near crossover. The 12 db/octave stabilization in the instrumentation oscillator application furnishes high loop gain and full drive to higher frequencies, plus lower wide-band noise and greater freedom from rate-limiting problems, than would be possible with the same closed-loop bandwidth using more conventional 6 db/octave stabilization.

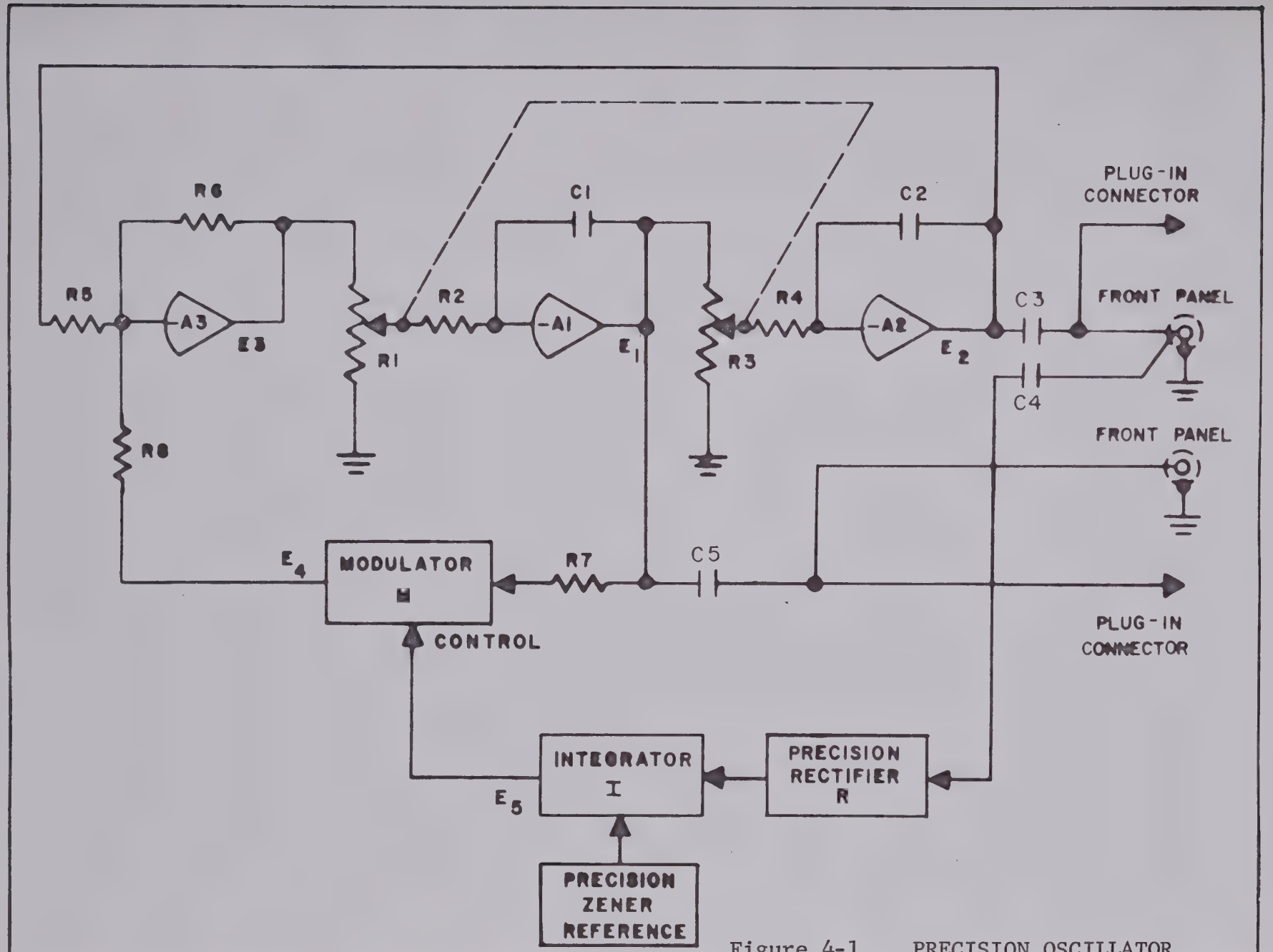



Figure 4-1 PRECISION OSCILLATOR

# SECTION 5

# CALIBRATION

This section includes a complete calibration procedure for the Model DVO-102 oscillator. Adjustments need not be made in the sequence listed.

## 5.1. FREQUENCY AND CONTROL VOLTAGE ADJUSTMENT

a. Using a Weston PR840 RMS to DC Converter or equivalent and an electronic counter, record ØA output when the frequency is set to 10 kHz on the highest range. Adjust trim capacitors C15 on the SW1-C and SW1-D boards until the following simultaneously occur:

Counter on ØA reads 10,000 ± 50 Hz

ØB output magnitude is the same as ØA within ±0.2%

It will be found that the clockwise rotation of C15 on either SW1-C or SW1-D will cause the frequency to decrease. However, it will also be found that the clockwise rotation of C15 on SW1-D causes ØB magnitude to decrease while the clockwise rotation of C15 on SW1-C causes ØB magnitude to increase.

b. Note the peak-to-peak magnitude of the signal on the test jack of the A4 board with an oscilloscope as the most significant dial is swept from 1 to 10 on the highest range. Adjust the trim resistor R10 on SW1-D until the peak-to-peak magnitude is never greater than 500mV nor less than 20mV.

c. With the RMS to DC converter and the counter, record ØA output when the most significant dial is set at 10 on the highest range. Readjust trim capacitors C15 on the SW1-C and SW1-D boards until the following occur simultaneously:

Counter on ØA reads 100,000 ±500 Hz

ØB output magnitude is the same as ØA within ± 2%

5.1.1. Repeat steps 5.1-a, 5.1-b, and 5.1-c until all are simultaneously within their specified limits.

5.2. AMPLITUDE ADJUSTMENT

With a thermal-transfer standard (Weston 1573 or equivalent) on ØA set the main dial at 10 and the range switch at 100. Adjust the trim resistor R9 on the A4 board until the voltage magnitude is 12.110 volts ±.01%.

5.3. FREQUENCY RESPONSE ADJUSTMENT

Trim capacitor C13 on the A4 board was provided to adjust the high-frequency response of the oscillator, but it has not been required on most units. It is not anticipated that the frequency response should normally require readjustment during the life of the equipment. If the high-frequency response seems to be outside of specification limits, excessive control voltage range is the most likely cause; repeat section 5.1-b. The only type of commercially-available equipment which is sufficiently accurate for these measurements to 100 kHz is the Hermach type high-frequency, thermal-transfer standard (Englehard Industries - Part No. 34970-10C) or equivalent.

## 5.4. SETTLING TIME ADJUSTMENT

a. In order to maintain a reasonably constant low-level dc offset out of the A2 integrator as the frequency is swept over its full range, a trim potentiometer R50 has been included on the A1 board. This adjustment establishes a constant dc level at the main output coupling capacitors in order to reduce tuning-transients and minimize settling time.

b. Turn the DVO "off" and remove the A4 board. Attach a dc oscilloscope to the test jack on the A3 board (Pin E of the A3 board). Set the most significant dial to 10 on the highest range. Turn the DVO "on" and note the dc level as read on the oscilloscope. Using the 10 position of this dial as a reference, slowly step the setting down to the 1 position. Adjust the trim potentiometer R50 on the A1 board until the maximum change of dc level is less than 10mV at any dial position.

c. Turn the DVO "off", and replace the A4 board. Turn the DVO "on" again and check to insure that signals exist at the ØA and ØB connectors.

Loose Leaf Industries, Inc.
HILLSIDE, N.J.

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